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PALEONTOLOGY.—*Reclassification of the Rotaliidea (Foraminifera) and two new Cretaceous forms resembling Elphidium*¹. ALAN H. SMOUT, Iraq Petroleum Co., Ltd., London, England. (Communicated by Alfred R. Loeblich, Jr.)

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The two species of Foraminifera to be described herein, *Elphidiella multiscissurata*, n. sp., and *Fissoelphidium operculiferum*, n. gen. and n. sp., are small, planispiral forms with shell material of radially arranged, perforate calcite. They show secondary thickening and have a canal system. They usually occur together in Maestrichtian marls that contain many well known index species, notably *Siderolites calcitrapoides* Lamarck, 1801, *Omphalocyclus macropora* Lamarck, 1816, and *Trechmanella persica* L. R. Cox, 1934. The accuracy of the age attribution can be taken as of a very high order. *E. multiscissurata* has a close resemblance to species referred to *Elphidiella* Cushman, 1936, but differs in having a carinate margin and slight grooves on the chamber walls, originating from the rows of pores on the radial sutures. *F. operculiferum* is an unusual species with a system of fissures and granules arranged very similarly to those on the ventral side of the test in *Rotalia trochidiformis* Lamarck, 1804.

The systematic position of these species presents a nomenclatorial problem that has

been confused by the inclusion with the radial, canaliculate Foraminifera of others that have shell material of a different nature. The superfamily Rotaliidea has been shown (Smout, 1954) to have a type species, *Rotalia trochidiformis* Lamarck, 1804, in which the shell material is radial, perforate calcite (Wood, 1949), deposited in laminae that correspond each to a chamber, each covering the whole test. A canal system is present. The Foraminifera that have tests of this character form a compact group within which phylogeny is relatively easy to trace. In addition, there is no known case where intergradation with non-caliculate genera occurs, with the exception of some highly complex derivatives of canaliculate species. There is a strong case for restricting the superfamily Rotaliidea to the laminated, radial, canaliculate genera. The otherwise similar but non-caliculate genera (Discorbidea Smout, 1954) are the nearest group to the Rotaliidea, and are probably ancestral to them. They typically have an aperture while the Rotaliidea have no aperture or a few pores on the terminal face. The interiomarginal slit found in the septa of many Rotaliidea does not correspond to a former aperture. The remainder of the Foraminifera that are traditionally placed in the Rotaliidea are completely unrelated to them. These include the Spirillinidae, Nonionidae (excluding *Elphidium* etc.), and the genera *Archaeodiscus* Brady, 1873, and *Nummulostegina* Schubert, 1907. The trochoid, granulate, perforate group of Wood (1949), eg. *Gyroidina* d'Orbigny, 1826, must also be removed from the Rotaliidea. The more

¹ This work is published by permission of the chairman and directors of the Iraq Petroleum Co. and was carried out under the direction of Dr. F. R. S. Henson. My thanks are due to Dr. P. Bermudez, Dr. P. Brönnimann, and Dr. R. Bataller for gifts of comparative material and to G. F. Elliott for bibliographical assistance. The new species were first named, described, and figured by A. N. Dusenbury in an unpublished company report on which we collaborated, and use has been made of his observations. The type specimens are deposited in the British Museum (Natural History), South Kensington, London. Topotypes are deposited in the U. S. National Museum, Washington, D. C.

recent taxonomic work, by Glaessner (1945) Hofker (1951), Sigal in Piveteau (1952), Bermudez (1952), Loeblich and Tappan (1953), and others, shows a progressive tendency to sort out the canaliculate Foraminifera from the others, but the process has not been carried to its logical conclusion because there was no underlying theory. It is now possible to set up a classification with clear morphological definitions and reduce the points of ambiguity to those cases where the critical characters have not been recorded for a genus, or their determination cannot readily be undertaken. Practical difficulties do arise. In particular, the secondary thickening of fossil species may be overlooked, for it may be removed by solution, leaving only the primary chamber walls externally. Those whorls that are covered by later ones can be seen in thin sections to have been thickened. All the radial, perforate, spiral Foraminifera, other than the Lagenidea, may have to be reincorporated in the Rotaliidea, and may contain the ancestral species of the canaliculate families; but as no connection has yet been traced, the non-caliculate families can be omitted at present.

One may proceed to a major classification of the foraminifera that build the test of radial, laminated calcite:

Superfamily Lagenidea: Noncaliculate with a terminal or peripheral aperture.

Superfamily Discorbidea: Noncaliculate with an interior marginal aperture, areal aperture, or showing derivation from such a form.

Superfamily Rotaliidea: Caliculate with no aperture, or pores on the apertural face, or pores elsewhere, sometimes with interior marginal intercameral foramina, or showing derivation from such a form.

Superfamily ROTALIIDEA

The accompanying table of stratigraphical occurrences and probable phylogeny has been compiled with the characters of numerous species in mind, rather than the diagnostic generic characters. It is found that a number of phyletic groups can be recognised which have simple distinguishing characters, provided one is willing to redefine genera and families where necessary. The result is a classification that differs significantly from any proposed before but without

any general appearance of unfamiliarity. Five families can be very readily distinguished, and are natural phyletic groupings. The Nummulitidae have a distinctive marginal cord, the Elphidiidae have retral processes to the chambers, the Miogypsinidae have orbitoidal habit with an eccentric nucleoconch, the Rupertiidae are initially trochoid and are attached and the Baculogypsinidae have solid spines or spherical growth. Apart from a few highly specialized forms that obviously evolved from a member of these families, there is no necessity to make exceptions to these simple definitions. The Rotaliidae for the most part form an equally distinct group, being trochoid and not attached. They are the parent forms of the Miogypsinidae and the Rupertiidae. The family Miscellaneidae is used for all the difficult cases, but these have a similarity between themselves which, although it does not yield to simple definition or appear to indicate a monophyletic group, is reassuring to the taxonomist. It includes numerous species that are almost bilaterally symmetrical and are not easy to separate from species of *Rotalia* (*Neorotalia*) that have the dorsal and ventral sides similarly ornamented. It is suspected that genera of the Miscellaneidae have been differentiated repeatedly from *Neorotalia*. The strictly symmetrical species of the Miscellaneidae are thought to be related to asymmetrical ones in several cases. The Miscellaneidae have strong radial canals in all genera excepting *Sulcoperculina*, which is a very unusual form and a misfit in any family.

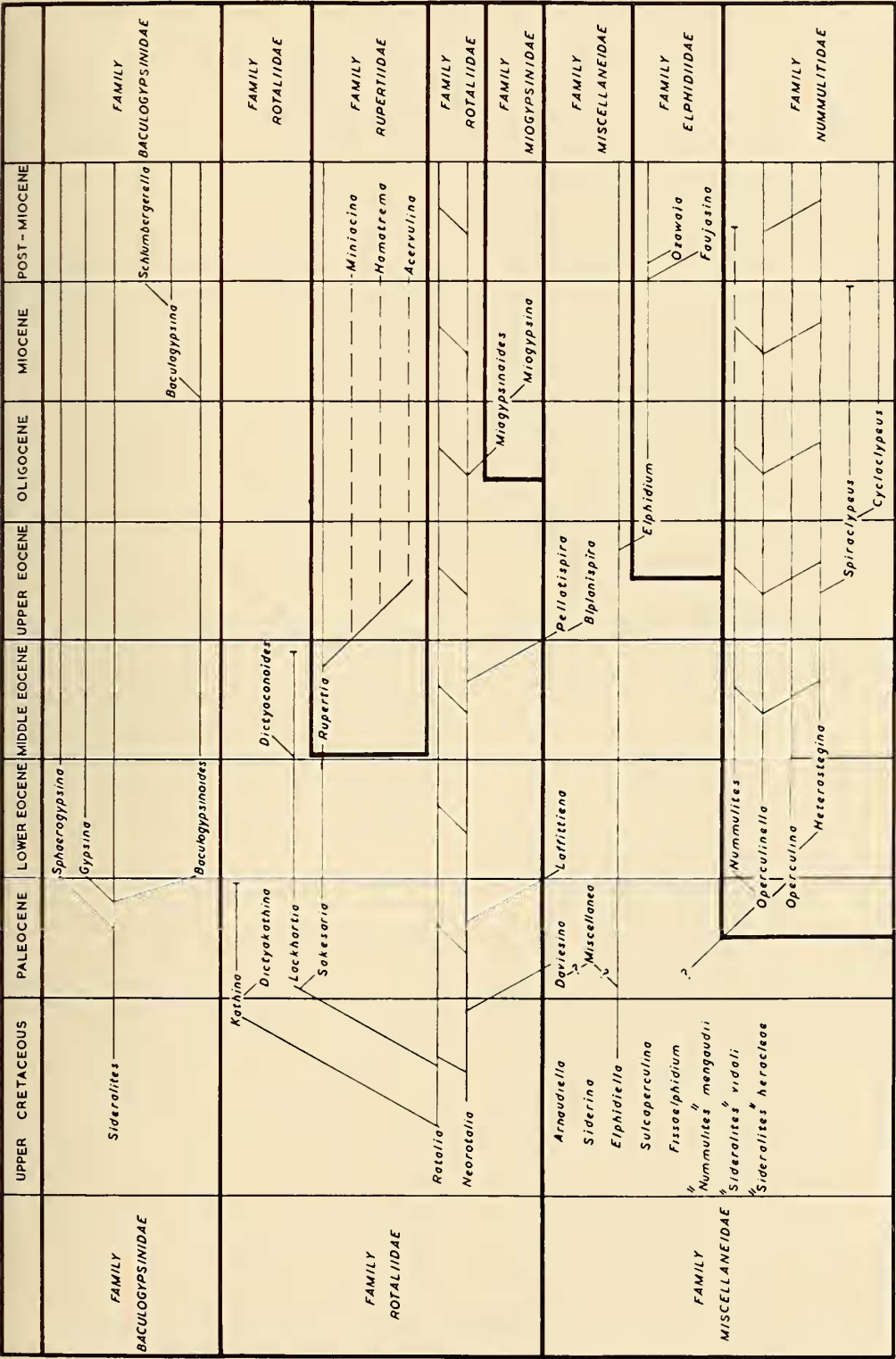
Family ROTALIIDAE

The test is trochoid and the dorsal and ventral surfaces are differentiated; all external openings being ventral, except for perforations. The canal system is various, but all genera have radial canals or fissures or umbilical cavities and intraseptal and subsutural canals are common if not universal.

<i>Rotalia</i> (<i>Streblus</i> , <i>Turbinulina</i> , <i>Ammonia</i> , <i>Hammonium</i>) ²	<i>Sakesaria</i> (<i>Eorupertia</i>)
<i>Neorotalia</i>	<i>Dictyoconoides</i>
<i>Kathina</i>	<i>Dictyokathina</i>
<i>Lockhartia</i>	<i>Notorotalia</i> ?

There is little to add to the discussion of this family given in a previous paper (Smout, 1954),

² Genera in parentheses are considered to be synonyms.



OCCURRENCE AND PROBABLE PHYLOGENY OF THE ROTALIIDAE

except as regards *Neorotalia* Bermudez, 1952. Bermudez has separated a group of species including *R. mexicana* Nuttall, 1928, and *R. viennoti* Greig, 1935. *R. calcar* d'Orbigny, 1826, should be included. The practical distinction between *Rotalia* and *Neorotalia* is not easy, but it is of great theoretical importance because *Neorotalia* is probably the persistent primitive stock of the superfamily Rotaliidea, and has probably given rise to a number of genera of the Miscellaneidae, as well as to the initial forms of some if not all families. Its most important characteristic is a distinct asymmetry without strong differentiation of the dorsal and ventral sides. From the origin of *Miogypsinoides*, it is known that this genus can give rise to bilaterally symmetrical families. It is obviously closely related to many species of the Miscellaneidae, but no more closely than to *Rotalia* itself. The definitely trochoid Rotaliidae give rise only to the family Rupertiidae.

Occurrence.—Upper Cretaceous to Recent.

Family RUPERTIIDAE

The test is primitively trochoid but may be arborescent or acervuline. It is attached by the apex.

<i>Homotrema</i>	<i>Carpenteria</i>
<i>Sporadotrema</i>	<i>Acervulina</i> ?
<i>Miniacina</i>	<i>Victoriella</i>
<i>Rupertia</i>	

Rupertia and *Homotrema* are often placed in different families, but they merely represent evolutionary stages of one lineage. *Sakesaria*, of the Rotaliidae is thought to have become attached by the apex in the early stages; becoming *Rupertia*. The latter genus shows two tendencies. The axis may branch, as in the arborescent genera, or the chambers may be irregularly added in later stages, leading to *Carpenteria* and probably to *Acervulina*. There is a possibility that *Gypsina* belongs here, rather than in the Baculogypsinidae.

Occurrence.—Eocene to Recent.

Family MIOGYPSINIDAE

The test has orbitoidal median chambers, eccentrically arranged around the nucleoconch, often with lateral chambers. The adult is bilaterally symmetrical but the nepionic stage is primitively like *Neorotalia*.

Miogypsina
Miogypsinoides

Miolepidocyclus
Miogypsinopsis

The position and character of this family are generally recognized. These genera form a lineage derived from *Neorotalia*.

Occurrence.—Upper Oligocene and Miocene.

Family DISCOCYCLINIDAE

This family belongs to the radial, perforate group of Foraminifera but its origin is not known. There are no obvious canals and there is a probability that the Discocyclinidae are derived from the Discorbidea.

Occurrence.—Eocene.

Family ORBITOIDIDAE

This family as at present recognized as polyphyletic. None of the genera have an obvious canal system. Some genera are suspected of being derived from the Rotaliidae.

Occurrence.—Upper Cretaceous to Recent.

Family ELPHIDIIDAE

"Tests free, planispiral, trochoid or uncoiling; wall calcareous, hyaline, perforate radial in structure, with a canal system opening into a single or double row of pores along the sutures, and with retral processes projecting across the sutures; aperture consisting of a single slit or row of pores at the base of the apertural face, or scattered pores on the face."

<i>Elphidium</i> (<i>Polystomella</i>)	<i>Elphidioides</i>
<i>Faujasina</i>	<i>Ozawaia</i>
<i>Criboelphidium</i>	<i>Polystomellina</i>

Loeblich and Tappan (1953) proposed the definition given above. There is practical difficulty in separating those species that really have retral processes from those that have lateral ornament that gives a similar appearance. The general resemblance between genera of the Miscellaneidae and the Elphidiidae can be very great (see Figs. 6 a, b and 10 a, b). By definition *Elphidiella* has no retral processes and therefore has been removed to the Miscellaneidae. *Noto-rotalia* Finlay, 1939, probably is without retral processes and is provisionally placed in the Rotaliidae. The Elphidiidae retain the canal system and variability of the symmetry which are shown by their ancestral family, although it is

unusual for one species to show such variability as do those of the Miscellaneidae. It is not proven that any genus has an interiomarginal aperture, although it is sometimes present as an intercameral foramen.

Occurrence.—Upper Eocene?, Oligocene to Recent.

Family BACULOGYPSINIDAE

The test is primitively planispiral or trochoid, but the dorsal and ventral surfaces are not differentiated. The canal system is diffuse and confused with the perforations. The margin is rounded or absent. Advanced genera may become globular. Large spines are often present and are formed by the thickening and not by marginal projections of the chambers.

<i>Siderolites</i> (<i>Tinoporus</i>)	<i>Gypsina</i> ?
<i>Baculogypsina</i>	<i>Sphaerogypsina</i> ?
<i>Baculogypsinoides</i>	
<i>Silvestriella</i>)	

The spinose genera show a close resemblance to each other that leaves little doubt that they should be associated in one family. The canal system is very diffuse and should not be considered the same as that of the Miscellaneidae. The origin of *Gypsina* Carter, 1877, and *Sphaerogypsina* Galloway, 1933, is obscure and it is not certain that they should be included here; perhaps they belong to the Homotremidae.

Occurrence.—Upper Cretaceous to Recent.

Family NUMMULITIDAE

The test is planispiral and bilaterally symmetrical. The canal system is fine and ramifying without vertical canals or fissures and the margin has a differentiated marginal cord containing ramifying canals.

Subfamily NUMMULITINAE³

<i>Nummulites</i> (<i>Camerina</i>)	<i>Assilina</i>
<i>Operculina</i>	<i>Ranikothalia</i>
<i>Operculinoides</i>	<i>Paraspiroclypeus</i>
<i>Operculinella</i>	

Subfamily HETEROSTEGININAE

Heterostegina
Spiroclypeus
Cycloclypeus

There has been a very great measure of agreement about this family, but a failure to state categorically that it is the nature of the canal system, particularly that of the marginal cord, that is the distinctive character from the other Rotaliidea, particularly from the Miscellaneidae. The marginal cord of the Heterosteginidae is sometimes suppressed by the reduction of thickening that automatically occurs in cyclical genera.

Occurrence.—Upper Paleocene to Recent.

Family MISCELLANEIDAE

The test is planispiral or trochoid but not differentiated in structure into obviously dorsal and ventral sides. The canal system is strongly developed with subsutural and intraseptal canals and either vertical canals or a system of fissures. There is no differentiated marginal cord. There are no spines or retral processes. A few aberrant genera have a complex spire or have lateral chambers.

<i>Laffiteina</i>	<i>Daviesina</i>
<i>Pellatispira</i>	<i>Sulcoperculina</i>
<i>Biplanispira</i>	<i>Fissoelphidium</i>
<i>Miscellanea</i>	<i>Elphidiella</i>
<i>Arnaudiella</i>	<i>'Siderolites' vidali</i> and <i>'S.'</i>
<i>Siderina</i> ?	<i>heracleae</i>
	<i>Pellatispirella</i> ?

The differences between some of these genera become very slight when the protean nature of the group is realized and the changes of canal system and tendency to asymmetry are no longer regarded as features on which to distinguish families in this particular group of genera. Advanced forms such as *Biplanispira* Umbgrove, 1937, are included when they are isolated end-forms and clearly derived from typical genera of the family. *Elphidiella* is traditionally classified with *Elphidium* Montfort, 1808, and is probably the ancestral genus to the Elphidiidae, but it lacks the retral processes that are the only real justification for recognizing the Elphidiidae as a family distinct from the Miscellaneidae. It is logical to include difficult primitive forms in the Miscellaneidae. *Sulcoperculina* has no canaliculate marginal cord but it has a highly differentiated margin, which is unusual in the Miscellaneidae.

The genera *Calcarina* d'Orbigny, 1826, and *Siderolites* Lamarek, 1801, have been used as familial types without a clear decision about their characters. *Calcarina* is variously stated to have

³ The inclusion of these genera is not intended to indicate an opinion on their validity. A number of names not in general use have been ignored.

C. calcar d'Orbigny, 1826, and *Nautilus spengleri* Gmelin, 1756, as the type species. D'Orbigny based his generic description and model on *C. calcar*, but the species was neither described nor figured. No reference to any previous work was cited for this species and the model does not constitute a valid indication of a species according to the Rules of Zoological Nomenclature. *C. calcar* d'Orbigny, 1826, is therefore a nomen nudum and its subsequent validation cannot affect the designation of *N. spengleri* by Cushman (1915), for this was a valid species included in the original list of species of *Calcarina* by d'Orbigny. *C. calcar* is not congeneric with *N. spengleri* for the spines of the former are produced from the marginal regions of the chambers, whereas the spines of *N. spengleri* are formed by the thickening, and are of the same nature as pillars and pustules. *C. calcar* is either a *Rotalia* or belongs to a genus closely related to *Rotalia*. *N. spengleri* belongs to the genus *Siderolites* Lamarck, 1801. The resemblance between it and *S. calcitrapoides* Lamarck, 1801, the type species of *Siderolites*, is so close that arguments have been put up for their identity. A specific distinction can be maintained but there is no necessity for generic distinction and similar species are found at various Tertiary horizons to link the geological record of *Siderolites* from the Upper Cretaceous to the Holocene. The refusal to admit *Siderolites* as a long-ranging genus with Tertiary species has coincided with the attribution of the Cretaceous species *Siderolites vidali* Douville, 1907, and *S. heracleae* Arni, 1932, to it. They have no spines and no closer resemblance to *Siderolites* than to *Laffiteina* Marie, 1946, *Daviesina* Smout, 1954, or *Elphidiella* Cushman, 1936. They resemble *Daviesina* in the planispiral, very feebly trochoid habit but have definite vertical canals while *Daviesina* has a combination of canals and fissures. *Laffiteina* and *Elphidiella* have distinct canal patterns. A new generic name is required.⁴ All this establishes

⁴ **Pseudosiderolites**, n. gen. Type species, *Siderolites vidali* Douville, 1907. Test lenticular to biconical, bilaterally symmetrical; equitant chambers arranged in a plane spire. Shell material radially fibrous, laminated, perforate, composed of calcite. Radial canals numerous. Without spines, marginal canal or other marginal differentiation.

Other genera of the Miscellaneidae have the following distinctive characters: *Pellatospira* and *Biplanispira* are evolute; *Elphidiella*, *Laffiteina* and *Pellatipirella* have characteristic canal patterns;

clearly that *Calcarina* should not be used as the type of a family and that the Siderolitidae, if the name is to be used, must include *S. calcitrapoides* but not necessarily *S. vidali* or *S. heracleae*.

It has already been remarked that *Neorotalia* of the family *Rotaliidae* has a similarity to *Laffiteina* and *Daviesina* and forms a plexus of primitive species that is probably the origin of the more distinctive forms of both the *Rotaliidae* and the *Miscellaneidae*. The *Miscellaneidae* may represent derivatives of *Neorotalia* that tend to be planispiral rather than be a monophyletic group. The inclusion of *Neorotalia* in the *Miscellaneidae* would fit better with a phyletic picture, but the morphological distinction of *Neorotalia* from *Rotalia* is difficult and a family distinction between these genera is unthinkable at present.

The majority of the genera of the *Miscellaneidae* are bilaterally symmetrical and the inclusion of *Daviesina* and *Laffiteina* is therefore debatable. These genera are frankly intermediate between the *Rotaliidae* and the *Miscellaneidae* but the structure on the two sides of the test is essentially the same, as in the typical *Miscellaneidae* while the structure of the dorsal and ventral sides of the test in any species of the *Rotaliidae* is different as regards the development of canals and ornament as well as perforation and the alar prolongations of the chambers.

Occurrence.—Senonian to Recent.

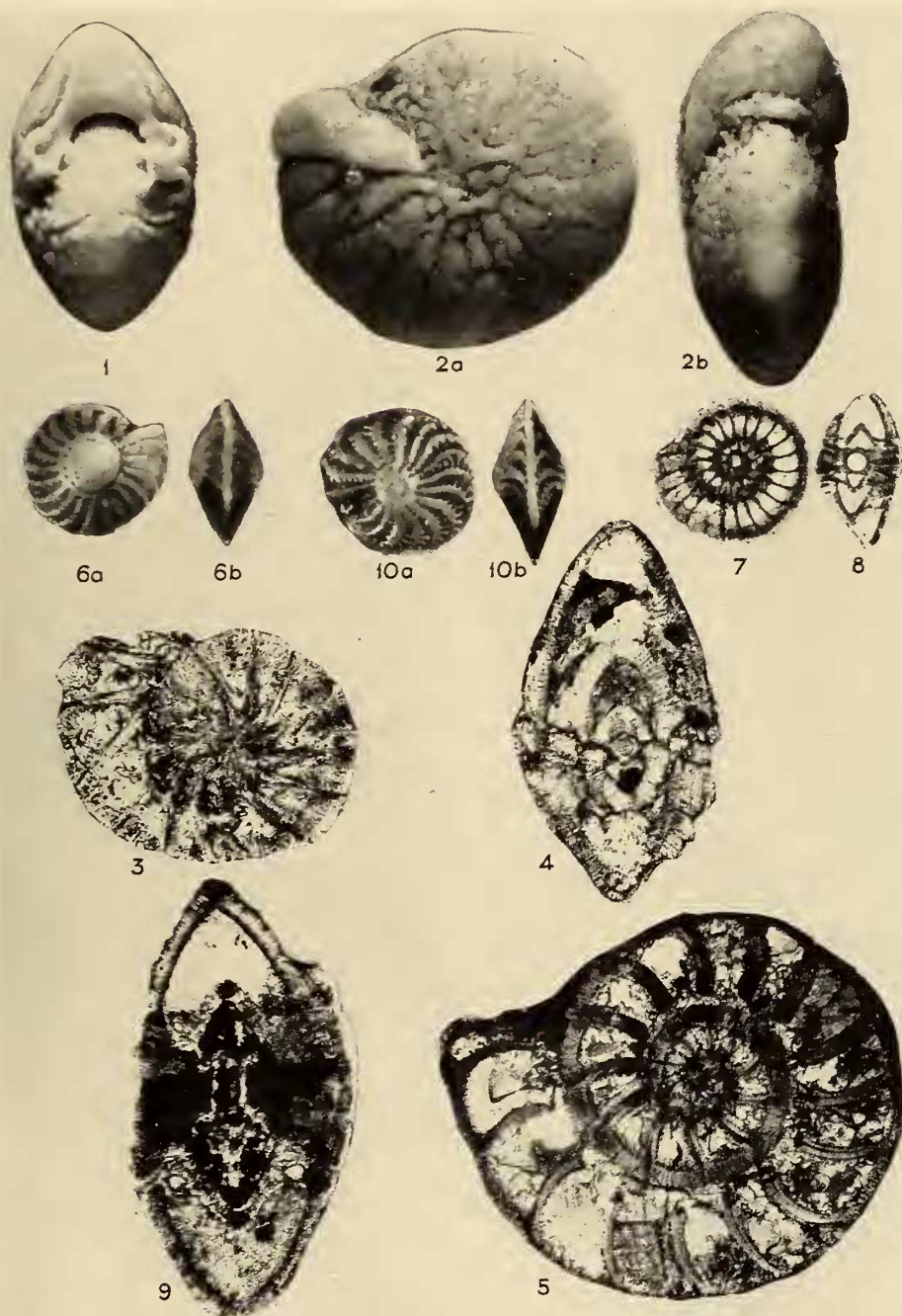
Genus *Elphidiella* Cushman, 1936

Type species, *Polystomella arctica* Parker and Jones, in Brady, 1864.

The test is bilaterally symmetrical and planispiral, with a simple spire of equitant chambers that usually leave an axial plug. There are sub-sutural and vertical canals that open along the radial and spiral sutures, usually forming a double row along each radial suture. The aperture consists of pores on the terminal face.

The species of this genus have no retral processes. Striate ornament that resembles them is sometimes present, caused by grooves that originate at the sutural pores and run on the chamber walls after the manner of trabeculae. In fossil specimens, it is sometimes very difficult to determine if retral processes are really present.

Miscellanea and *Fissoelphidium* have fissures, not radial canals; *Siderina* and *Daviesina* are obviously asymmetrical; *Siderolites* has spines; *Sulcoperculina* has a marginal sulcus and lacks radial canals; *Arnaudiella* has extra-spiral chambers.



FIGS. 1-5.—*Fissoelphidium operculiferum*, n. gen. and sp.: 1, Edge view, to show septum and broken chambers (B.M.N.H. P.42154); 2a, b, lateral and edge views of holotype (B.M.N.H. P.42155); 3, tangential section to show figures (B.M.N.H. P.42166); 4, axial section (B.M.N.H. P.42167); 5, equatorial section (B.M.N.H. P.42168). All $\times 30$.

FIGS. 6-9.—*Elphidiella multiscissurata*, n. sp.: 6a, b, Lateral and edge views of holotype (B.M.N.H. P.42169) $\times 30$; 7, equatorial section (B.M.N.H. P.42175) $\times 30$; 8, axial section (B.M.N.H. P.42176) $\times 30$; 9, axial section (B.M.N.H. P.42177) $\times 100$.

FIG. 10.—*Elphidium* cf. *E. crispum* Linné: Pliocene, Abu Shareb, Levant. 10a, b, Lateral and edge views for comparison with Figs. 6a, b (B.M.N.H. P.42178) $\times 30$.

Some species that have been described as *Elphidium* lack retral processes; even in some cases when the latter have been recorded as present there is a doubt of the accuracy of the observations.

Elphidiella is already known to occur throughout the Tertiary. Brotzen records *E. prima* (Ten Dem, 1944) from the Paleocene. *Nummulites mengandi* Astre, 1924, is possibly an *Elphidiella*, but the typical canal system has not been demonstrated in this Upper Cretaceous species.

The typical unornamented species have little resemblance to *Laffitteina*, but there is no further difference between the two genera other than the symmetry of the test, itself not a marked feature.

Occurrence.—Maestrichtian to Recent.

***Elphidiella multiscissurata*, n. sp.**

Figs. 6-9

Holotype P.42169 and paratypes P.42170-7, British Museum (Natural History), and topotype P.2026, U. S. National Museum.

Description.—The test is composed of hyaline, radially fibrous, perforate calcite and is laminated in the usual manner of the Rotaliidea. It is small and lenticular to biconical with a subacute, feebly carinate margin. The spire is simple and planispiral and the chambers are involute and equitant. The umbonal region on each side is about one third of the diameter of the test and occupied by a boss that is usually slightly raised. The chambers of the last half whorl are separated from the boss by a groove, which is continued as a spiral of about one and a half turns of pores. Only the last whorl of chambers is visible externally. The sutures are radial and slightly curved, limbate mostly but incised for the last few chambers. Each suture has a row of about 10 pores on each side of the test. They incline alternately forward and backward over the chambers, with tributary grooves that are inconspicuous over the latest chambers, but become more obvious on the older, thickened chamber walls. The alternate inclination of the sutural canals makes the row of pores appear double. There are no retral processes, nor any rudiments of them, but this can only be seen clearly on the last two or three chambers, which are often not preserved. The aperture is cribrate, being a row of about 10 pores in the interiomarginal position. No intercameral foramina have been observed

with certainty. The proloculum is small and spherical. Dimorphism has not been observed.

Dimensions.—Diameter, 0.9 to 0.5 mm; thickness, 0.5 to 0.2 mm; diameter of nucleconch, about 0.01 mm.

There are about three whorls with 20 to 25 chambers in the last whorl.

Distribution.—It has been found in Maestrichtian marls in deep boreholes on Jebel Dukhan, Qatar, Arabia, associated with *Siderolites calcitrapoides* Lamarck, 1801, *Omphalocyclus macropora* (Lamarck, 1816), *Loftusia morgani* Douvillé, 1904, *Lepidorbitoides socialis* (Leymerie, 1851), *Orbitoides apiculata* Schlumberger, 1902, and *Fissoelphidium operculiferum* gen. et sp. nov. It is also found at Aqra, N. E. Iraq in Maestrichtian limestones with the same associated species and in addition *Loftusia persica* Brady, 1869, *Cyclolites* spp. and *Trechmanella persica* L. R. Cox, 1934.

Remarks.—There is a difficulty in deciding the correct generic attribution of this species. The formal resemblance to *Elphidiella* is very considerable, but the latter genus typically has a rounded margin, whereas *E. multiscissurata* has a marked differentiation of the marginal region. A similar difference appears to occur between species of *Elphidium*, and it need not be taken as a generic character. The slight grooving on the chamber walls of *E. multiscissurata* is not typical of *Elphidiella*, but again is not a character that need be considered as generic.

The very striking resemblance of *E. multiscissurata* to *Elphidium crispum* (Linné, 1758) is more apparent than real because this species has no retral processes. '*Nummulites*' *mengaudi* Astre, 1924, from the Upper Cretaceous of Aquitaine is possibly an *Elphidiella*. It resembles *E. multiscissurata* very closely but has a rounded margin without a carina and the canal system may be different. In any case they are distinct species. *Elphidiella prima* (Ten Dam, 1944), fide Brotzen, 1948, from the Danian and Paleocene of Sweden and Holland also lacks a carinate margin and cannot be the same species.

***Fissoelphidium*, n. gen.**

Type species, *Fissoelphidium operculiferum*, n.sp.

Description.—The test is planispiral and bilaterally symmetrical with a single spire of equitant chambers. The shell material is radially

fibrous, perforate calcite, deposited in laminae that correspond to the chambers and build up a spiral lamina and polar plugs as in *Nummulites*. The septa are double and there is a lateral system of wide meandrine fissures. The septa are double in appearance in thin section, particularly in tangential sections, for the fissures penetrate slightly into them. The margin is rounded and without a marginal cord.

Remarks.—This monotypic genus has a system of fissures resembling that of the ventral surface of *Rotalia*, but in *Fissoelphidium* they are found on both sides of the test. The dendritic fissures along the sutures recall the patterns formed by the canals in *Laffiteina*. The general appearance is suggestive of the Elphiidae, but there are no retral processes and there is no close resemblance to any species of *Elphidium*.

Occurrence.—Maestrichtian.

***Fissoelphidium operculiferum*, n.sp.**

Figs. 1-5

Holotype P.42155 and paratypes P.42154, 42156-69, British Museum (Natural History), and topotypes P.2027, U. S. National Museum.

Description.—The shell material is hyaline, radially fibrous, perforate calcite, deposited in laminae that correspond each to a chamber, and thus form a spiral lamina and supplemental thickening in the same manner as in *Nummulites*. The slightly curved septa appear double in section and there is a canal system. The test is stoutly lenticular with a rounded margin and no trace of a marginal cord or carina. The chambers are arranged in a simple, plain spire. They are equitant with nearly straight, radial, alar prolongations that do not reach the poles. The radial sutures are incised. On the latest chambers they are straight, but small alternating branches of them increase in strength on the older parts of the test. Toward the periphery they render the suture line zig-zag, while nearer the poles they form anastomoses and cut the supplementary skeleton into incised granules. These grade imperceptibly into the incised granules of the umbonal regions. The initial branches of the septal sutures tend to be directed forward, producing a pattern that has a similarity to that of *Laffiteina*. The lowest parts of the fissures seem to be cut off to form a canal system of lateral spiral canals and tributary canals, all

these running in the sutures. At the periphery the tributary canals become narrower and open into the fissures, and the spiral canals open into the fissures near the terminal chamber. The canals lie deep, but still in the peripheral part of the septum, and the sutural fissures penetrate a short way into the septa. There is no evidence of canals in the more central part of the septa. The perforations are coarse and evenly distributed. The proloculum is small and no dimorphism has been observed. The aperture consists of pores round an apertural plate that bulges outward. This is removed when the next chamber is formed, leaving an interiomarginal intercameral slit in the septum.

Dimensions.—Diameter, 2.2 to 1.3 mm; thickness, 1.0 to 0.5 mm; diameter of proloculum, 0.08 to 0.04 mm.

There are about three whorls with 12 to 15 chambers in the last whorl.

Distribution.—Type locality: Maestrichtian of Dukham Oilfield, Qatar Peninsula of Arabia, with *Elphidiella multiscissurata* and the fauna listed as accompanying that species.

Other localities: Maestrichtian of N. Iraq at Aqra, with *E. multiscissurata* and the same associated fauna and at Jebel Gara; in S. Iraq in the Maestrichtian of the Zubair Oilfield, near Basra; at Ras Sharwain, Qishn, (Mahra, Persian Gulf) where it is also of Maestrichtian age.

The system of deep fissures is probably a primitive character. As in *Miscellanea* and *Kathina* grooves and fissures are the equivalent of the canal system of more advanced genera. This aberrant species shows little similarity to any other but is probably closely related phyletically to the other Cretaceous Miscellaneidae. '*Nummulites*' *mengaudi* Astre has a similar appearance in photographs of thin sections. This is odd because neither fissures nor canals are mentioned in the type description. These two species might prove to be congeneric on further investigation, but they are unlikely to be identical. The dimensions of *F. operculiferum* are considerably greater than those of '*N.*' *mengaudii*.

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BOTANY.—*New Korean grasses and new names of grasses to be validated before publication of a manual of the grasses of Korea*. IN-CHO CHUNG, Botanical Gardens, University of Michigan. (Communicated by H. H. Bartlett.)

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The writer has prepared a *Manual of the grasses of Korea* which, before publication as a book, will be microfilmed, since it has been presented as a dissertation at the University of Michigan. Since publication by microfilm is not recognized as valid by the International Rules of Botanical Nomenclature, it is necessary to extract for prior journal

publication the new Korean taxa which are proposed, as well as certain names in new combinations required for uniformity of treatment in the *Manual*.

The purpose of the *Manual* is to give full descriptions, with clear-cut keys to all categories, of all known grasses of Korea, both South and North. The only grasses excluded